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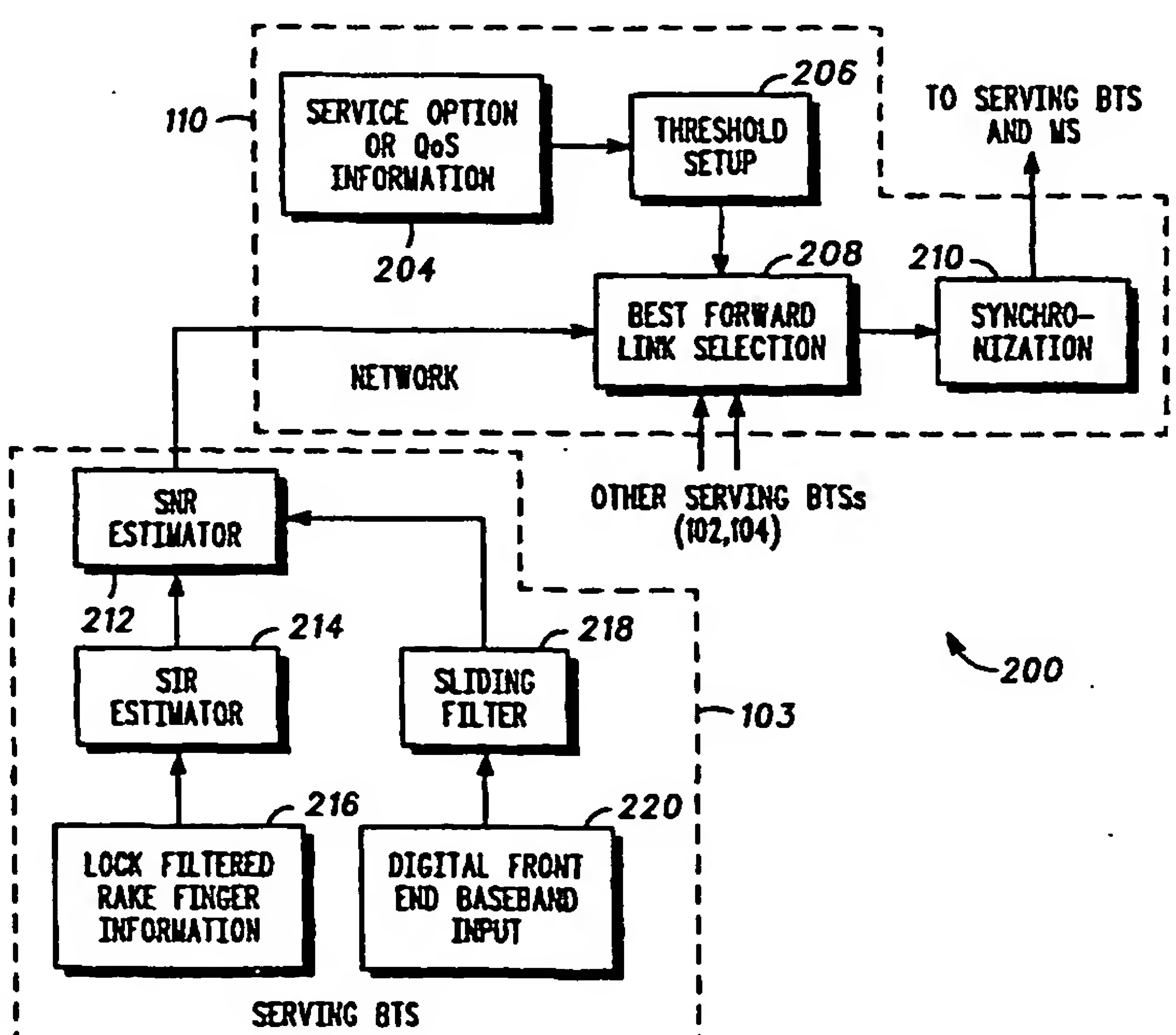
(54) Title: LINK SELECTION IN A COMMUNICATION SYSTEM



(57) Abstract: At least one active link for packet data communications in a wireless communication system is selected. The reverse link is measured for a plurality of active base transmission stations (102-104) serving a mobile station (108). A subset of active links having a highest signal measurement is selected for forward transmission of at least one packet data communication.

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LINK SELECTION IN A COMMUNICATION SYSTEM

FIELD OF THE INVENTION

The present invention pertains to forward channel control, and more particularly to a method an apparatus for selecting a forward link with reduced overhead.

BACKGROUND OF THE INVENTION

In code division multiple access (CDMA) systems, communications in the forward link occur over multiple channels from different base transceiver stations (BTS). The forward link is for communications from the BTS to the mobile station (MS). The reverse link is for communications from the MS to the BTS. The channels over which communications occurs in the forward direction are commonly called the "active set", such that the active set of channels are the channels that the mobile station receiver demodulates. A so called "neighbor set" of channels is also monitored, although not demodulated, for purposes of soft handoff.

The larger the number of channels over which a signal is communicated to a mobile station, the better the diversity performance. However, this improvement in performance is gained at the expense of the overall system capacity as fewer channels will be available for other mobile stations, and at some loading point the diversity gain will be less than the extra power transmitted on all of the soft handoff forward links. Accordingly, there is a trade off between performance and capacity in CDMA systems.

For packet data, the bit error rate (BER) is achieved with forward error correction schemes like automatic repeat request (ARQ). The target forward error rate (FER) is anticipated to be in the 10% to 15% range for packet data. The diversity benefit of multiple paths due to soft handoff is significantly smaller when targeting this higher forward error rate

compared to the target 1% forward error rate in voice transmissions, or the target forward error rate of 0.1% in circuit data transmissions.

Accordingly, what is needed is improved forward channel selection for packet data communications in a CDMA system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1. is a block diagram illustrating a cellular communication system.

FIG. 2. is a functional block diagram illustrating the operation of the network.

DETAILED DESCRIPTION OF THE DRAWINGS

At least one active link for packet data communications in a wireless communication system is selected. The reverse link is measured for a plurality of active base transmission stations (102-104) serving a mobile station (108). A subset of active links having a highest signal measurement is selected for forward transmission of at least one packet data communication.

A forward transmission scheme is proposed for transmitting data on the best forward link, or the best subset of forward transmission links. Link performance results for static and highly Ricean channels, such as experienced by fixed wireless terminals, show that it is better to transmit data on the best forward link among all of the active serving base transceiver stations. Transmission on the best or the best two forward links instead of all of the forward links reduces the required communication bandwidth (backhaul bandwidth) between the base transceiver stations and the infrastructure (network) responsible for controlling, coordinating, and initializing base transceiver stations, typically known as the cellular base station controller (CBSC), or radio network controller (RNC), or the selection/distribution unit (SDU). Transmission on the best two forward links can also improve system capacity when the total power from n+1 (e.g., n+1=3) forward links associated with soft or softer handoff to achieve a desired FER for a given user exceeds the required power if only n or fewer forward links are used.

As used herein, a link is a collection of channels used to communicate between a mobile station and a base transceiver station. Channels can includes dedicated control channels, pilot channels, supplemental channels, paging channels and the like.

A cellular system 100 is disclosed in FIG. 1. The illustrated cellular system 100 is a code division multiple access system including a plurality of base transceiver stations (BTS) 102-104 in communication with a mobile station MS 108 that communicate over respective wireless communication paths. Those skilled in the art will recognize that typically more than three base transceivers and more than one mobile station will be present in a system. The base transmission stations 102-103 are connected to a mobile switching system network 110. CDMA cellular systems of this type are well known.

In a CDMA system 100, the voice target frame error rate (FER) is 1%, and the circuit target FER is 0.1%. For these target FERs, soft handoff provides a diversity gain. Therefore, it is preferable to use all of the available soft handoff links. However, for third generation (3G) packet data applications, the desired bit error rate (BER) is achieved with automatic repeat request (ARQ) since the target FER is anticipated to be in the 10% to 15% range. The diversity benefit of multiple paths due to soft handoff is much smaller when targeting these significantly higher FERs, as compared to targeting 1% in voice or 0.1% in circuit data.

Each communication path between a base terminal station 102-104 and a mobile station 108 has a forward link and a backward link. The network 110 is to select the forward link or links with the smallest transmission loss. If the mobile station measures the forward transmission links from base terminal stations 102-104, then measurements made by the mobile (e.g., the SNR (Ec/Io) measurements sent using pilot strength measurement messages (PSMM) as in IS 95 and IS2000 standards) must be communicated back the base transceiver stations and then to the network 110. This requires message overhead, which is undesirable. The overhead can be substantially eliminated by using the reverse channel signal measurements to detect and determine the best subset of the active

channels, which subset is to be used for forward channel packet data communications.

For example, the forward channel packet data channels can be determined by the reverse link signal to noise ratio (SNR) which each of the base station transceivers 102-104 obtains from the reverse link signal received from mobile station 108 and the overall interference plus noise power (RSSI) measured. The advantage of using the reverse link signal is that the mobile need not use messaging to communicate to the base station transceivers 102-104 the forward link signal to interference ratio (SIR). The reverse link channel SIR can be estimated from the reverse channel pilot (IS2000 standard) or the winning Walsh symbol energy (IS95A,B standard), and is proportional to Ew/Nt or pilot Ec/Nt, respectively. The resulting measurement (SNR) is a signal to (thermal) noise plus interference ratio which is computed from the reverse link SIR and RSSI.

Each serving base transceiver station (BTS) 102-104 sends its reverse signal to noise ratio (SNR) to the network selection distribution unit (SDU) 110 which typically reside in the radio network controller (RNC) or centralized base site controller (CBSC) on a frame-by frame basis. If one of the currently serving BTS (i.e., one of the BTSs in the active set of the mobile station) involves more than one sector in the call (this is typically called softer handoff where more than one station is serving the mobile), then the best signal to noise ratio of the softer handoff sector is selected as the signal to noise ratio of the serving base transmission station. The network (SDU) 110 selects either the best one forward link, or the best subset of the active forward links, for packet data transmission. A threshold driven by the current service option and/or the target FER can be used for the selection of the best channel. Depending on the threshold, either the best forward link or the best subset of the forward link channels is selected. The SDU synchronizes both the BTSs and the MS for transmitting and receiving the forward data.

FIG. 2 is a functional flow chart illustrating operation of the network 110, which may for example be a mobile switching center, and the serving base transceiver station (illustrated to be BTS2 103). The base

transceiver station 103 receives lock filtered rake finger information in step 216, as is known in the art. The BTS calculates the signal to interference ration in step 214 for each of the locked filtered rake finger information signals in step 214. This SIR information is provided to the signal to noise ratio estimator 212. The total signal plus noise power is also estimated at the base station transceiver (RSSI) and the interference rise (RISE) 108 above the receiver thermal noise floor is computed as RISE = RSSI-RSSInoload where each quantity is in dB. The resulting RISE is also input to the signal to noise ratio estimator 212 as is indicated in step 220. The sliding filter, as is known in the art, filters the baseband input in step 218. The resulting filtered signal is also used for the SNR estimation as indicated in step 212. The SNR is communicated to the network 110 along with the other signal measurements from the other active, or serving BTSs 102, 104.

The network 110 is responsive to desired FER in the network server (indicated by step 204) to setup a threshold in step 206. In the preferred embodiment, the threshold indicates how close the weaker links must be to the strongest link in dB. If the threshold is 5dB then the base station transceivers with the SNR or signal strength (S) within 5 dB of the strongest transceiver are part of the reduced active set and hence will be assigned forward links on the next transmission. The higher the FER target, then the smaller the threshold (e.g, for a higher target, the threshold may be 3 dB. The best forward link selection is made in step 208. This is the step in which the network controller, which can be a computer or microcontroller, or other suitable system, selects the subset of active, or serving, BTSs for data packet transmission. Once selected, the packet of data is communicated by the serving BTS selected. A new BTS may be selected for each packet communication, or the serving BTS may be selected at a predetermined interval.

One way to calculate the SNR is to compute the signal to interference ratio (SIR) and the reverse link interference rise above the noise floor (RISE). The SNR can be calculated as follows:

$$SNR(i)=SIR(i) + RISE(i) \text{ in dB}, i = 1,\dots,N \qquad (1)$$

where i represents the ith serving base transceiver station (BTS), and N represents N soft handoff legs. The SIR can be calculated by accumulating filtered rake finger energy values. The SIR energy can be based on the reverse link pilot or the demodulated symbol energy (of the reverse link signal received by the BTS over the control or data channel (e.g., in IS95, IS2000 the channel could be the fundamental channel (FCH), dedicated control channel (DCCH), or the supplemental control channel (SCH)), such that:

$$\mathrm{SIR}(i) = \sum_{j=1}^{M} E(j) \qquad (2)$$

where E(j) represents the jth filtered finger energy value, and M represents M fingers. The reverse link interference rise relative to the noise floor (RISE) is calculated below:

$$RISE(i) = (RSSI(i) - RSSInoload(i)) \qquad (3)$$

where RSSI is the base transceiver station (BTS) received signal strength indication, which is updated every frame as is known in the art. The RSSInoload(i) is the BTS received signal strength when the BTS is not loaded with any traffic. It is determined by site calibration or can be calculated based on the nominal noise figure expected for the BTS as is known in the art. The RSSI can be obtained by low pass or ranking or trim mean filtering the baseband front end signal samples over some time period (e.g., 2 seconds). Note that it is possible to compute the signal energy (S) and use it in Eq. 4 below instead of the SNR. More particularly, S is calculated using RSSI where S(i) = SIR(i)*RSSI(i). It will be recognized by those skilled in the art that S(i)= SIR(i) + RSSI(i) in dB. SIR can also be estimated from a decoder metric, such as the decoder total metric, the winning walsh (data) symbol energy as produced in the non-coherent receiver of in IS95A and IS95B compliant communication device.

The SDU selection function selects the best forward link Flink(k), or the best subset of forward links, based on a threshold as given by:

$$Flink(k) = Best(SNR(1), SNR(2), \ldots, SNR(N)) \qquad (4)$$

where k=1,2...,K for the total number of selected forward links that pass the threshold. The Best() function select the best link, or subset of links, from the available SNR measurements for the soft handoff legs. Alternatively, in eh other preferred embodiment, the Best() function is based on signal power measurement S(i) as noted above.

It is envisioned that the updates to the best forward links will be generated frequently. By obtaining frequent updates, a smaller delay will be experienced and a more accurate selection of the best forward links for the next scheduled packet transmission. the more the selection of the link, the more likely the burst will be received without errors with the lowest possible power. This in turn produces higher system capacity.

A best forward link selection scheme is thus proposed which does not rely on forward link measurement Ec/Io (e.g., pilot Ec/Io measurements sent via PSMMs) measured at the mobile such as is known for voice transmissions, but rather only on a reverse link signal measurement, such as the RSSI or the SNR measurement at the BTS. Each serving base transceiver station (BTS) provides its reverse link SNR to the network SDU. The SDU chooses the forward link, or forward links, whose reverse link SNR exceeds a predetermined threshold and has the best signal level. The SDU then synchronizes the BTS to transmit, and the mobile station (MS) to receive, the data burst. The scheme provides a performance improvement for packet data, and maintains the flexibility for circuit data or voice in keeping with the soft handoff diversity benefit by selecting for transmission the best subset of forward links.

We claim:

CLAIMS

1. A method of selecting at least one active link for packet data communications in a wireless communication system, comprising the steps of:

measuring a reverse link at a plurality of active base transmission stations; and

selecting a subset of active links having a highest signal measurement for forward transmission of at least one packet data communication.

2. The method according to claim 1 wherein the subset comprises a single channel.

3. The method according to claim 1 wherein the measurements are a function of the reverse link RSSI.

4. The method according to claim 3 wherein the measurements are a function of the reverse link signal to noise ratio.

5. The method according to claim 1 wherein the measurement is a function of the reverse link signal to noise ratio.

6. The method according to claim 1 wherein the measurements are a function of RSSI and SIR.

7. The method according to claim 1, wherein the measurements in are RSSI + SIR in dB.

8. The method of claim 1, wherein a measurement is made and sent back to the network device to determine the best forward link for every frame interval.

9. The method of claim1, wherein a measurement is sent back from every serving base station transceiver to the network device on every frame interval.

10. The method of claim 1, further including the step of using measurements from all BTS serving a mobile station to determine a best forward link.

11. The method of claim 1, wherein the measurements are a function of a decoder metric.

12. The method of claim 1 wherein the subset of active links used for packet communications is a smaller than the full set of active links.

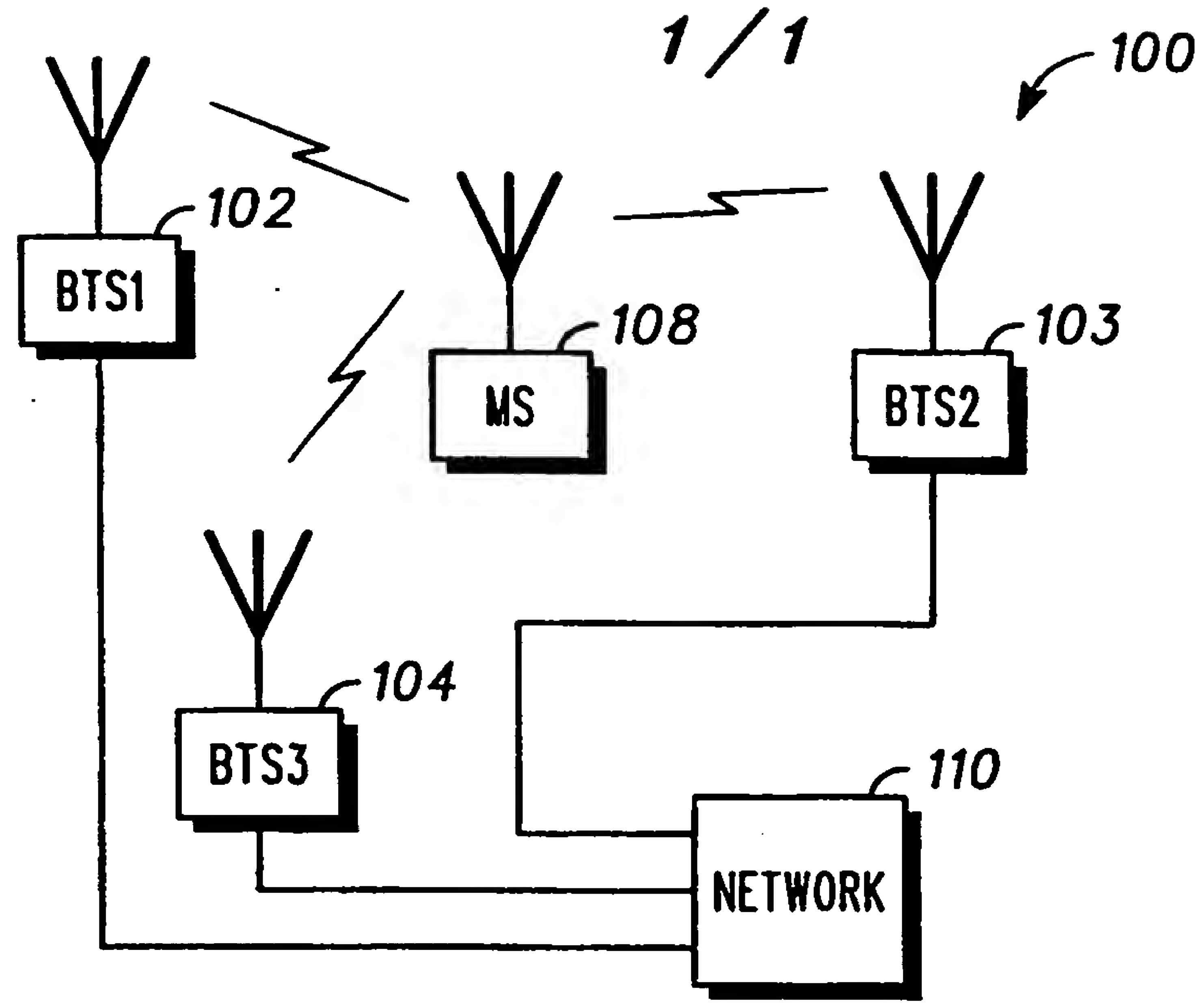
100
102
BTS1
108
MS
103
BTS2
104
BTS3
110
NETWORK

FIG.1

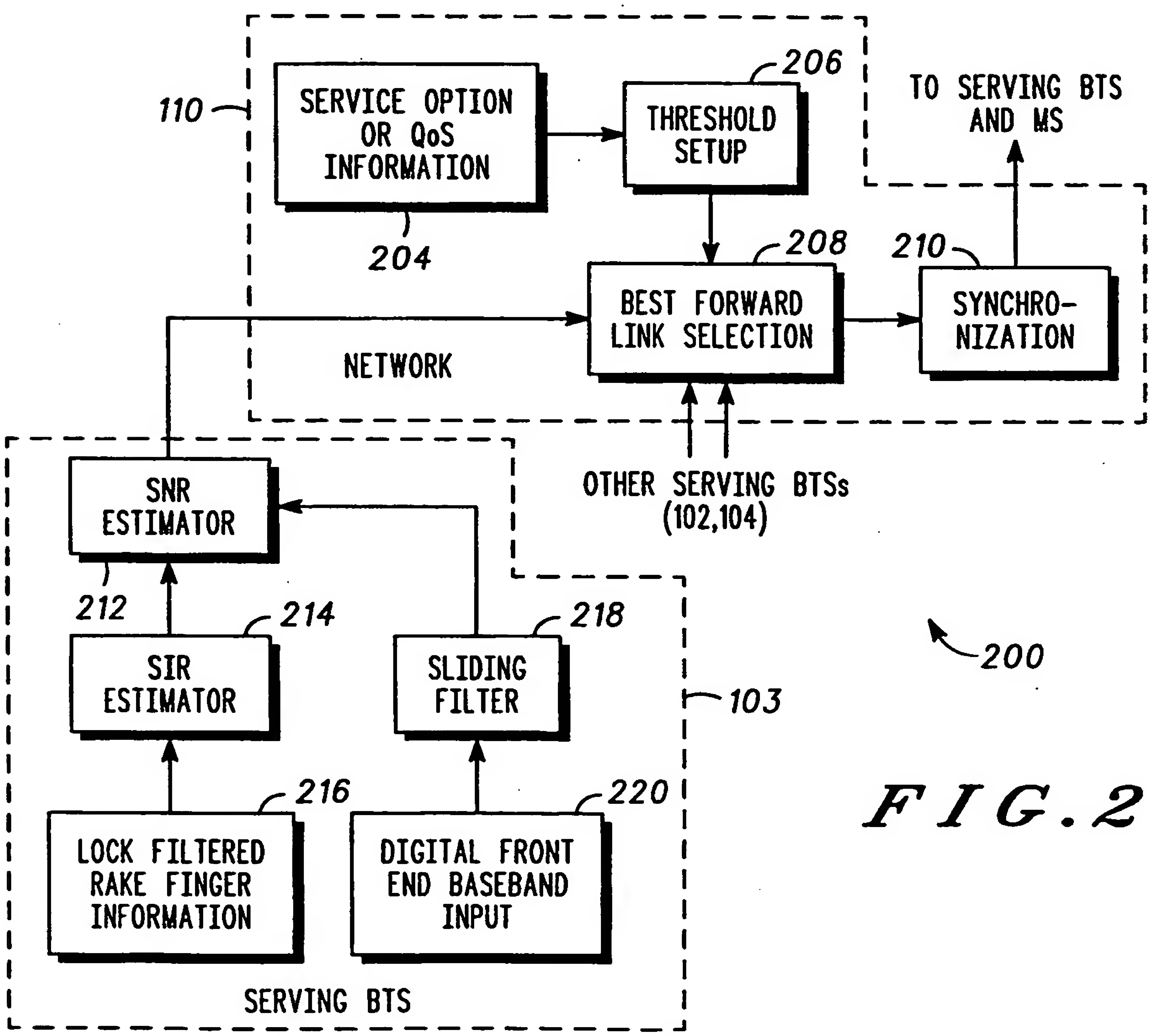
110
SERVICE OPTION OR QoS INFORMATION
204
206
THRESHOLD SETUP
TO SERVING BTS AND MS
208
BEST FORWARD LINK SELECTION
210
SYNCHRO-NIZATION
NETWORK
OTHER SERVING BTSs (102,104)
SNR ESTIMATOR
212
214
SIR ESTIMATOR
218
SLIDING FILTER
103
200
216
LOCK FILTERED RAKE FINGER INFORMATION
220
DIGITAL FRONT END BASEBAND INPUT
SERVING BTS

FIG.2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/24707

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) :H04B 7/00
US CL :Please See Extra Sheet.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 455/62, 63, 509, 513, 450, 455; 370/317, 318, 320, 322, 328, 329, 331, 332, 333, 335, 341, 342, 437

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
RSSI, S?R, INTERFERENC$4 SAME (POWER ADJ1 CONTROL$4), SELECT$4 SAME CHANNEL$4, CDMA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,590,409 A (SAWAHASHI et al) 31 December 1996, col.5, line 61 to col.7, line 41, and see figures 4-7	1-12
X	US 5,886,988 A (YUN et al) 23 March 1999, col.5, lines 26-59, and see figures 3a-4, 6-7, col.18, 44 to col.20, line 17, and col.20, line 27 to col.23, line 3.	1-12
Y	US 4,977,612 A (WILSON) 11 December 1990, figures 4 and 7, col.8, line 18 to col.9, line 51.	1-12
Y	US 5,666,654 A (KANAI) 09 September 1997, figures 1, 4B, 6B	1-12
Y	US 5,491,837 A (HAARTSEN) 13 February 1996, figures 5-6	1-12

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/24707

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,603,082 A (HAMABE) 11 February 1997, figures 2-3, col.5, line 18 to col.7, line 53.	1-12
X	US 5,093,924 A (TOSHIYUKI et al) 03 March 1992, figures 3-5, 8	1-12

Form PCT/ISA/210 (continuation of second sheet) (July 1998)★

INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

455/62, 63, 509, 513, 450, 455; 370/317, 318, 320, 322, 328, 329, 331, 332, 333, 335, 341, 342, 437